GEOPHYSICS RESEARCH DIRECTORATE
AIR FORCE CAMBRIDGE RESEARCH CENTER

HEIGHT OF CONSTANT PRESSURE SURFACE BETWEEN 80 AND 120 THOUSAND FEET

by

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Problem:

The variability in height of constant pressure surfaces between 80 and 100 thousand must be considered in the design of altitude control mechanisms which will enable a high altitude balloon to maintain a constant geometric altitude above sea level. Information on the variation in height of such surface with latitude, longitude, season, synoptic pattern and time of day is required.

Response:

Radiosonde pressure height measurements above 80,000 feet have been relatively scarce until very recently. Improved balloon performance since 1957 has greatly increased the number of ascents above this level. Unfortunately, the observed heights of isobaric surfaces become less accurate with increasing altitude due to systematic errors in temperature measurements produced by solar radiation. This systematic effect of radiation varies greatly with solar elevation at time of observations and with the type of radiosonde instrumentation used.

Radiation temperature correction systems used by many countries are only rough approximations in the region above 20 kilometers. In many cases, the error in the height measurement of an isobaric surface equals or exceeds the day to day variations around the mean monthly height. Consequently, the data from each

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country must be carefully evaluated before it can be used to determine variations in the height of isobaric surfaces at high altitudes.

The Free University of Berlin conducted a study, ("Mean Seasonal Conditions of the Atmosphere at Altitudes of 20 to 30 km and Cross Sections -- Along Selected Meridians in the Northern Hemisphere") using all available radiosonde data and extrapolation techniques to obtain a series of charts showing the mean monthly heights of the 20 millibar pressure surface (roughly 84,000 ft) over the Northern Hemisphere. This study provides the best available estimates on the variability with latitude, longitude and season of an isobaric surface at the altitude of interest. The variability of an isobaric surface in the vicinity of 120,000 feet probably will be slightly greater than those at 84,000 feet but will be of the same order of magnitude.

The following table taken from data in the study referenced above shows the mean heights (meters) for the mid-season months of the 20 millibar pressure surface at various latitudes along four meridians of the Northern Hemisphere:

January

	Longitude				
Latitude	90°W	160°W	10°E	140°E	Longitudinal Range
30°	26300	26370	26300	26380	80
40°	26200	26340	26200	26260	140
50°	26080	26280	26000	26040	280
60°	25780	26160	25780	25800	380
70°	25480	25900	25440	25580	460
80°	25300	25480	25180	25360	368
90°	25200	25200	25200	25200	0
Latitudinal Range	1120	1170	1120	1180	

April

Latitude	Longitude 90°W	160°W	10°E	140°E	Longitudinal Range
30°	26450	26460	26480	26500	50
40°	26440	26480	26470	26500	60
50°	26420	26520	26440	26480	100
60°	26400	26500	26400	26440	100
70°	26380	26440	26380	26400	60
80°	26370	26380	26320	26360	60
90°	26300	26320	26340	26330	40
Latitudinal Range	150	200	160	170	

July

Latitude	Longitude 90°W	160°W	10°E	140°E	Longitudinal Range
30°	26780	26780	26820	26840	60
40°	26880	26900	26920	26940	60
50°	27000	27020	27020	27040	40
60°	27100	27100	27120	27080	40
70°	27180	27160	27160	27200	40
80°	27240	27220	27240	27240	20
90°	27250	27250	27240	27230	20
Latitudinal Range	470	470	420	390	

October

Latitude	Longitude 90°W	160°W	10°E	140°E	Longitudinal Range
30°	26560	26560	26560	26600	40
40°	26540	26560	26520	26600	80
50°	26440	26530	26420	[illegible]	20
60°	26300	26440	26300	26340	140
70°	26100	26250	26100	26140	150
80°	26000	26020	25880	25960	60
90°	25880	25860	25860	25860	20
Latitudinal Range	680	700	700	740	

The yearly range (summer to winter) of mean monthly heights (meters) of the 20 millibar pressure surface at various latitudes for four meridians of the Northern Hemisphere:

	Longitude			
Latitude	90°W	160°W	10°E	140°E
30°N	480	410	520	460
40°N	680	560	720	680
50°N	920	740	1020	1000
60°N	1320	940	1340	1280
70°N	1700	1260	1720	1620
80°N	1940	1740	2060	1880
90°N	2050	2050	2050	2050

From the above tables it is possible to obtain estimates of the seasonal, latitudinal and longitudinal variations in the mean monthly height of the 20 millibar pressure surface. For example, the mean height of the 20 mb surface at 70°N, 90°W in January is 25480 meters, in July it is 27180 meters, a seasonal range of 1700 meters. The latitudinal range is greatest in January; heights range from approximately 26400 meters at 30°N to 25200 meters at 90°N.

The mean monthly heights of the 10 millibar surface for three stations in the Northern Hemisphere (taken from an Army Ballistic Missile Agency report - No. DA-TR-61-59) are shown in Fig. 1. These heights are based on relatively few observations. Values are not given for the winter months at Thule due to bursting of balloons in the extremely cold polar atmosphere. These data are not considered to be as reliable as the 20 mb heights given above. However, they give some indication of the seasonal and latitudinal variability of the 10 mb surface.

Information on the day to day variability around mean monthly heights at this altitude is not readily available. However, a limited

amount of data for pressure surfaces at slightly lower levels (22 to 23 kilometers) indicate the following day to day variations around monthly mean heights between 30 and 60 degrees north.

Standard Deviations (meters) Around Mean Seasonal Height

Latitude	Winter	Spring	Summer	Fall
30° to 40°N	110	105	95	90
50° to 60°N	210	150	130	175

Indications are that variations at levels between 25 and 35 kilometers will be 20 to 30 percent greater.

Studies of the diurnal variation in the height of the 25 millibar surface (about 25 kilometers) have been conducted over the United States. These studies indicate that the heights of the 25 millibar surface are 200 to 400 feet higher in daylight areas than in areas of darkness. These values may increase slightly with altitude.

The Perkin-Elmer Corporation letter requesting this study indicates an interest in the variability of the height of isobaric surfaces with distance. However, in telephone conversation with Mr. Norman Sissenwine of this Center, the requester indicated that these data are required for a design problem involving a constant level balloon. A free balloon will travel downstream with the wind. As the wind flow is nearly parallel to the contours (lines of equal height of an isobaric surface) variations in the height of a constant level balloon as it moves downstream with the wind will be nearly zero. The change in height with distance perpendicular to the wind is directly related to the wind speed. Data are available with which to compute these changes. However, from the information provided, it does not appear that this type of information is pertinent to this problem.